Space Weather Technical Forecast

Issued on Thursday, 16 June 2022 at 13:03 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-class flares throughout. Decreasing Chance of G1 (Minor Storm) conditions to end current UTC week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to become Moderate in the past 24 hours, with a solitary M1.3 flare emitted 16/0353UTC from sunspot region AR3031. This was one of up to nine sunspot regions on the current disc. The spot group itself showed an overall decrease in spot count and area in the 24 hours, however it retained its overall Mt Wilson and Zurich classifications of Eai/Beta-Delta, with the delta unchanged as the trailing group.

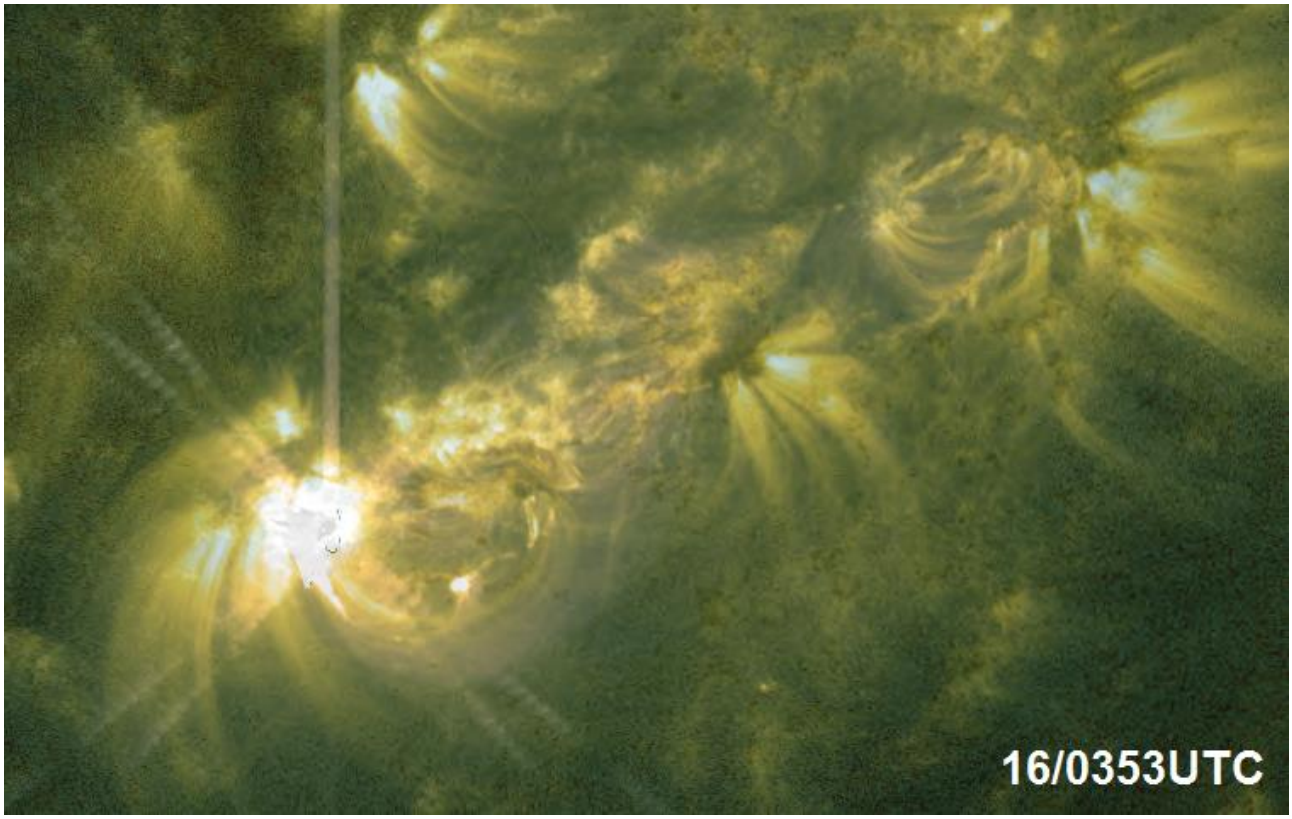

Figure 0: 16/0353UTC view of sunspot region AR3031 in AIA 171, 94 and HMIB. This trailing portion of the group retains a Mt Wilson delta spot, despite an apparent reduction in numbers of spots and overall area.

The GOES16 X-ray trace was otherwise perhaps unexpectedly flat in the period, with a gradual decline observed from C into high B-class, with no other groups offering a significant contribution to AR3031's efforts. In terms of trends, ARs 3037, 3030 and 3035 all showed proliferation of spots and growth, while all other areas were steady or in apparent decline. Near each limb, AR3036

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became less distinct in the west due to limb foreshortening and perhaps also a genuine simplifying trend, as a new region arrived in the northeast to manifest as a Cro/Beta by the period's end.

There are a few filaments present on the current disc, the largest of which is nestled to the east of (nominally) the second most complex spot group on the disc, AR3030, which appears as a Dai/Beta. This arrangement makes it one to watch, however as already stated it was unproductive in the 24 hours.

No Earth-directed CMEs were observed in available imagery. Events seen heading off-ecliptic to the southwest and northeast are not expected to affect Earth.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was symptomatic of the tail of influence from a Coronal Mass Ejection (CME), thought to be that emitted on 13 June and forecast to deliver a glancing blow to Earth.

To this end, the solar wind speed fell from an early high of 610km/s to reach 550, with the solar wind density slightly elevated around the cusp of double figures ppcc, but with a similar slight decline observed over the 24 hours. The IMF peaked early in the reporting window at 9nT, while the north-south component showed a drift from largely southward values and a nadir of -8nT, to an eventual +7nT peak before a more typical erratic trend resumed later in the UTC morning of 16 June.

The phi angle was negative (towards the sun) until 15/1400UTC, becoming positive thereafter, which may mask any contribution from onset of the expected CH90, and there is therefore a chance that this may have already commenced.

The net effect of the above solar wind measures was an early provisional peak of Active Kp '4o' in the 12-15UTC interval, otherwise gradually falling with time as both the speed and the anti-aligned component of Bz waned.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) measured by GOES16 remained very slightly above resting Background levels, but with no solar radiation storms thresholds reached.

Electron flux (greater than 2MeV) was at Normal Background to Moderate levels. Corresponding 24-hour integrated electron fluence has been well below the Active (1e8 integrated pfu) threshold, on a very slight rising trend. 3.95e6 integrated pfu was observed at 16/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of Moderate solar activity, largely from AR3031, although there are numerous regions on the current disc that may contribute. The front-side population does not alter significantly in the period, and so barring development, the daily Chance of M-class and Slight Chance of X persists unchanged throughout.

Solar Wind / Geomagnetic Activity: Solar winds are expected to be elevated through 16 to 18 June (days one to three) due to waning CME effects followed by coronal hole enhancements from CH90 and CH92. On day four (19 June) winds are expected to decrease as these coronal hole features rotate from a geoeffective position.

The initial Slight Chance of Minor Geomagnetic Storm G1 should gradually decrease through the coming four days, such that largely Quiet conditions should predominate by the end of the period.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10 MeV) is expected to be very near Background during the period, with a daily Slight Chance of an S1 or greater

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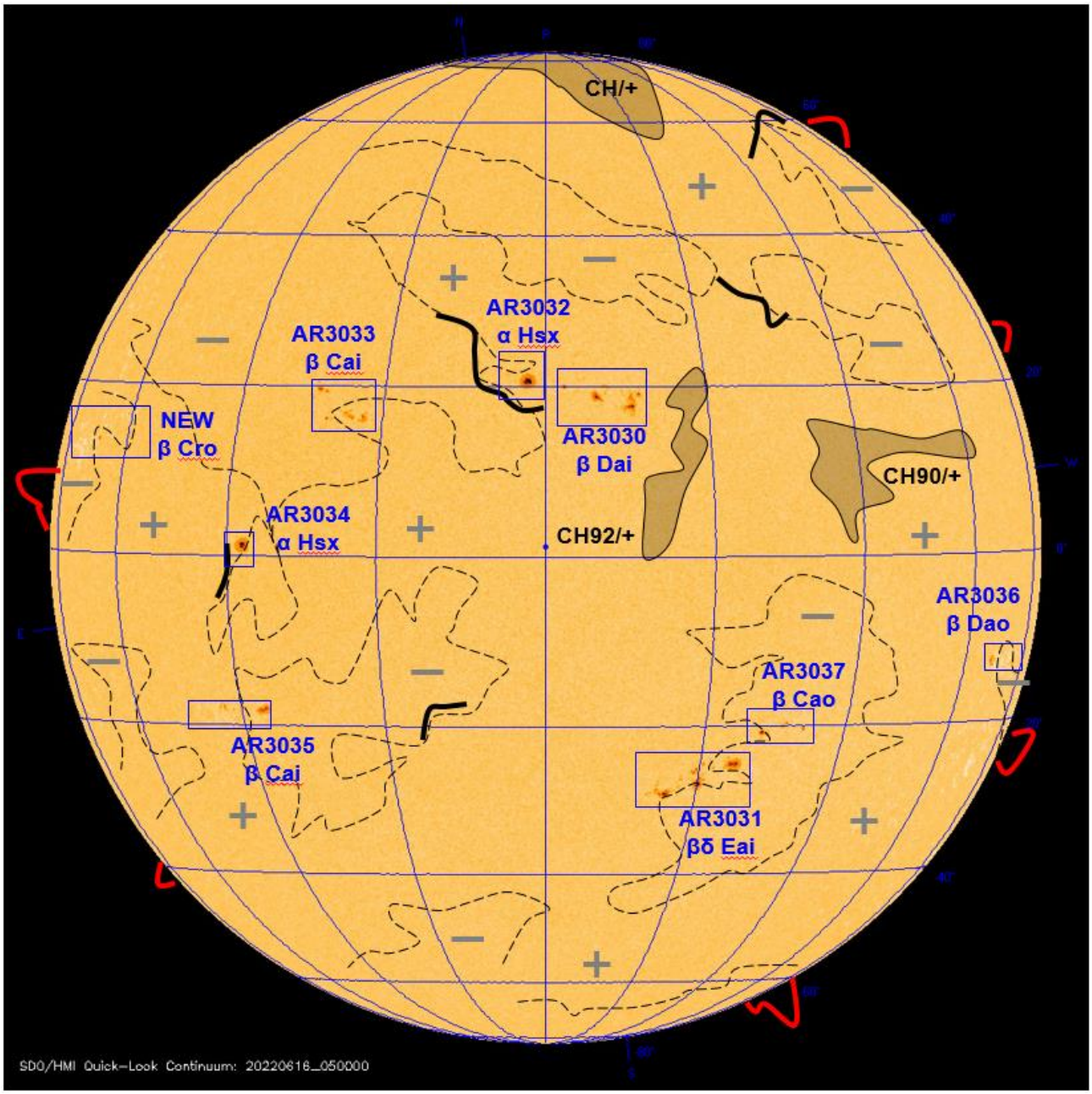
event occurring.

High energy electron flux (greater than 2 MeV) is expected to start at Normal Background levels, with a Chance of increasing to High levels later in the period due to high speed stream influences. Electron fluence is expected to follow a gradual rising trend, with a peak Chance of reaching Active (1e8 integrated pfu) levels by day four (Sunday 19 June).

Figure 1. Solar Analysis Valid 16/0500UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Prior to this 24-hour period, a sudden impulse was observed at L1 at around 15/0400UTC, likely the arrival of the anticipated glancing CME from 13 June. Solar winds briefly peaked around 620km/s, and have since shown a slow decline. No other CMEs are currently expected to affect Earth during the period.

Solar winds are expected to remain elevated through much of the forecast period. The rationale for this is Initially from to the waning effects of the 13 June CME, and then due to the successive high speed streams from coronal holes 90 and 92, which are anticipated early on day one (Thursday 16 June) and late 17 into 18 June UTC respectively. On day four (Sunday 19 June), solar winds should decline as these features rotate away from a geoeffective position.

Significant geomagnetic activity from the current vestigial CME effects is now considered to be unlikely, with perhaps a Slight Chance of G1 should Bz deviate southward for any significant length of time. The fact that CH90 and 92 have yet to convincingly manifest at STEREO A (admittedly in a CME polluted and data-deficient period), as well as their small size; our proximity the the solstice, and also their lack of activity on last pass, should all combine to perhaps offer a Slight Chance of G1, although Active is perhaps a more likely peak. Quiet conditions should have resumed by the end of the UTC weekend.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

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Radio Blackouts - X-Ray Flares:

There are currently up to nine sunspot regions on the Earth-facing disc.

Despite the congested disc, X-ray flare activity has been limited, with the background trace at GOES16 largely quiet apart from the intrusion of the M-class flare from AR3031. This group is dominant in terms of activity and stature, and it presents as an Eai/Beta-Delta. This group showed some recent decay in its intermediate and leading portions, however the trailing delta has been retained, and it was from this part of the spot that the 16/0352UTC M1.6 flare was generated.

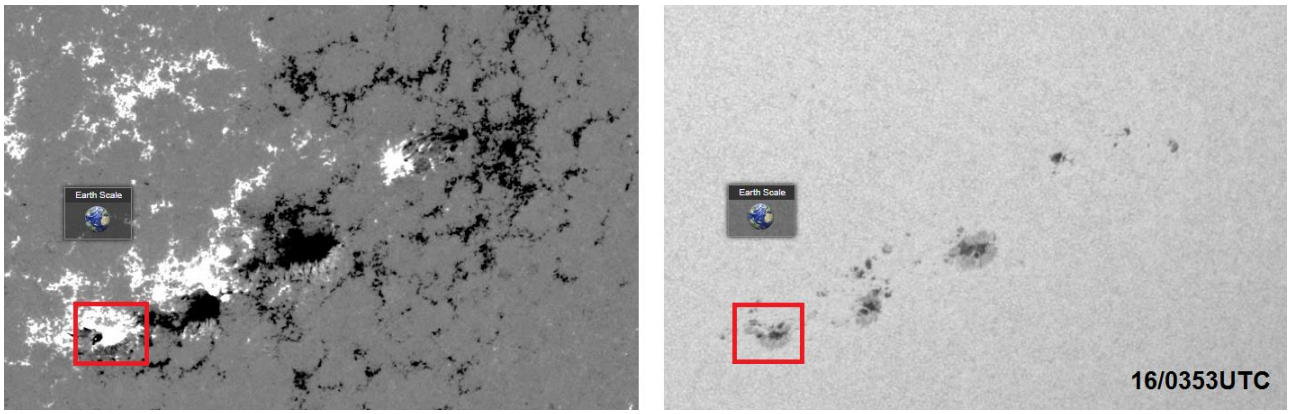
Other sunspot groups of note with growing and proliferating trends were AR3037, 3030 and 3035. Of these, nominally the most threatening was AR3030 near the meridian in the northern solar hemisphere. This group finished the past 24 hours as a Dai/Beta, however it was its growth that was the main feature of the period, as well as its proximity to the largest filament on the disc to its immediate east - a feature that it may destabilise should it flare significantly.

The balance of sunspot groups on the front side should remain largely unchanged in this period, with only apparently fading AR3036 leaving the disc, and with no obvious bright EUV regions evident on STEREO A EUVI imagery.

Barring development then, the flare risk is constant throughout, with a daily Chance of M-class flares and a Slight Chance of X.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: 16/0353UTC HMIB and HMI continuum imagery of AR3031 (left group) and AR3037 (upper right). The Mt Wilson delta spot has been shown boxed in red – this is the apparent source of the M1.3 flare.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) remains very slightly elevated, albeit comfortably below S1 in a damped and delayed response in the wake of the 13 June M3 flare.

The chances of enhancements of S1 or greater increase in this four-day period as a result of the westward advance of the current congested front side. Despite this, the risk should still only peak at a daily Slight Chance, with AR3031 remaining the main contributor to this risk.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	10	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Past four days in GOES16 proton flux, showing delayed and damped response to the M3 flare of 13 June. Similar such enhancements remain possible, perhaps more immediate and of greater magnitude given the current sunspots' western advance in the intervening days.

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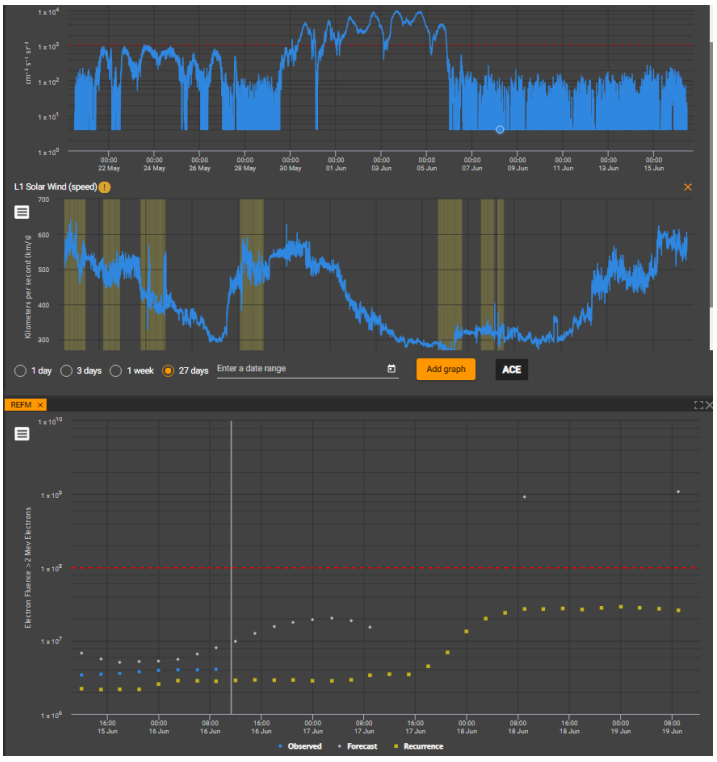
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at Normal Background to Moderate levels. Similar conditions are likely to continue for days one to three (16th-18th) due to the influence of geomagnetic activity from the sideswipe from the 13 June CME and possibly two coronal hole high speed streams that follow.

The risk of the electron flux becoming High should increase as the high speed streams wane into day four (Sunday 19 June). The corresponding electron fluence is therefore also expected to rise later in the period, but it is currently thought that it will remain below the Active (1e8 integrated pfu) threshold at this stage, with the REFM output considered to substantially too reactive in its Very Active suggestions in 72 hours' time (with unknown rationale in this case) - with even evidence from last rotation suggesting marginal Moderate to High flux is more likely.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	10	20	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Past 27 days in high energy electron flux at GOES16 (top), with causative L1 solar wind speed (middle) and 24-hour inetgrated fluence for past 24 hours also shown (bottom). The reasoning for REFM's Very Active 72-hour forecast is uncertain (white dots, lower plot), however it is felt to be a significant over-estimate and marginal High flux is preferred by the end of the coming four days.



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